Atmospheric Reactions

NREL

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Alternative Fuels Combustion Products

Vehicle being tested on chassis dynamometer

Subcontractor

Southwest Research Institute

Principal Investigator

Kevin Whitney
Southwest Research Institute
6220 Culebra Road
P.O. Drawer 28510
San Antonio, TX 78228-0510
(210) 522-5869

DOE Project Manager

Michael Gurevich
U.S. Department of Energy
CE-332, MS 6A-116/Forrestal
1000 Independence Avenue, SW
Washington, DC 20585
(202) 586-6104

NREL Technical Monitor

Michelle Bergin
NREL
1617 Cole Boulevard
Golden, CO 80401-3393
(303) 275-4429

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Scott Montgomery (303) 275-3193

Objective

This research program currently covers the following independent tasks:

(1) Analyze exhaust emissions from a light-duty vehicle modified to operate on butane, butane blends, and propane.

(2) Evaluate the effectiveness of NREL's variable-conductance-insulation (VCI) catalytic converter in reducing cold-start exhaust emissions after extended soak periods.

(3) Characterize small-diameter particulate matter from a light-duty vehicle operating in a simulated fuel-rich failure mode on Federal Reformulated Gasoline (RFG), M85 (85% methanol/15% gasoline), E85 (85% denatured ethanol/15% gasoline), liquefied petroleum gas (LPG) meeting HD-5 specifications, and compressed natural gas (CNG).

Approach

Each experimental approach given below corresponds numerically to the objectives listed above.

(1) Regulated exhaust emissions, speciated hydrocarbon emissions, ozone-forming potentials, and specific reactivity factors were determined for a TLEV-certi fied vehicle operating on 11 test fuels. These fuels included California Phase 2 gasoline, industry aver age gasoline, 100% propane, 100% n-butane, 90% n-butane/10% isobutane, 90% n-butane/10% mixed butenes, 60% n-butane/40% isobutane, 80% n-butane/20% propane, 90% n-butane/10% n-pentane, and 50% n-butane/50% propane. Utilizing the Federal Test Procedure (FTP), a total of 18 exhaust emissions tests were conducted on a light-duty vehicle equipped with a gaseous-fuel conversion kit. This task was jointly funded by NREL,ARCO, and Southwest Research Institute.

(2) Regulated exhaust emissions and estimated NMOG emissions from a TLEV-certified vehicle operating on E85 (85% denatured ethanol/15% gasoline) and

equipped with the VCI catalyst were determined utilizing the FTP. Five different combinations of vehicle preconditioning and soak period sequences were evaluated.

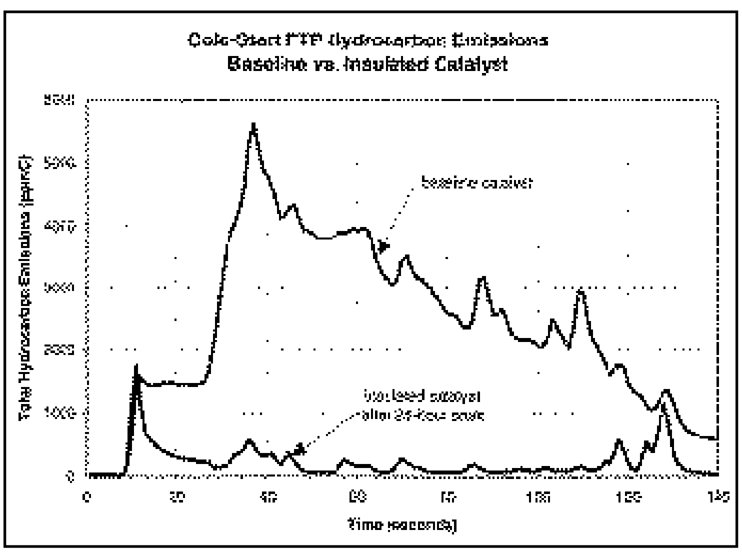
(3) Particulate and regulated gaseous emissions were characterized from a flexible-fueled vehicle operating on five different test fuels including CNG, LPG, M85, E85, and RFG. The vehicle was operated fuel-rich to simulate an engine failure mode for the increased production of particulate matter. Particulate emissions were characterized by total mass and particle size. A total of 10 exhaust emission evaluations were performed using the FTP.

Accomplishments

Results from each of the three independent objectives are given below:

(1) A vehicle modified with a gaseous fuels conversion kit met ULEV standards, at the mileage tested, while operating on all of the alternative fuels except a 100% n-butane fuel and a 90% n-butane/10% pentane fuel blend. The best emissions results were achieved with the vehicle operating on 100% propane, followed by a 50% n-butane/50% propane blend.

(2) Following extended vehicle preconditioning and a 24-hour soak period, the VCI catalyst reduced hydro carbon (HC) and carbon monoxide (CO) emissions by over 90% and oxides of nitrogen (NOx) emissions by 75% compared to the stock catalytic converter. After a standard vehicle prep and a 36-hour soak with the VCI system, HC, CO, and NOx exhaust emissions were reduced 30%, 20%, and 55%, respectively, compared to baseline levels. As expected, most of the emission reductions were achieved in the first few minutes of the cold-start phase of the FTP.



(3) Total particulate mass did not exceed the 1996 light-duty vehicle particulate emission standard for any of the fuels, even while operating at rich fuel/air equivalence ratios. The trend for total particulate mass emissions during rich operation was LPG < CNG < E85 < M85 < RFG. Particulate emissions during rich operation on LPG and CNG were similar to those observed for the vehicle while running at stoichiometry on gasoline.

Future Direction

This project is being extended to investigate the impact of winter temperatures and stoichiometric vehicle operation on particulate formation. Exhaust particulate will be characterized for total mass, size distribution, unburned oil contribution, polynuclear aromatic hydrocarbons, elemental content, and trace organic constituents. In addition, close-coupled light-off catalyst technology will be developed and evaluated for use on ethanol-fueled vehicles.

Publications

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Burch, S., Keyser, M., Colucci C., Potter T., Benson D. and Biel, J. (1996). “Application and Benefits of Catalytic Converter Thermal Management,” SAE Paper 961134.